Centers for Disease Control and Prevention
Epidemiology Program Office
Case Studies in Applied Epidemiology
No. 871-703

Screening for Antibody to the Human Immunodeficiency Virus

Instructor's Guide

Learning Objectives
After completing this case study, the participant should be able to:

- ☐ Define and perform calculations of sensitivity, specificity, predictive-value positive, and predictive-value negative;
- ☐ Describe the relationship between prevalence and predictive value;
- ☐ Discuss the trade-offs between sensitivity and specificity;
- ☐ List the principles of a good screening program.

This case study was developed in 1987 by Lyle Peterson, Guthrie Birkhead, and Richard Dicker.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service

PART I

In December 1982, a report in the *MMWR* described three persons who had developed acquired immunodeficiency syndrome (AIDS) but who had neither of the previously known risk factors for the disease: homosexual/bisexual activity with numerous partners and intravenous drug use. These three persons had previously received whole-blood transfusions. By 1983, widespread recognition of the problem of transfusion-related AIDS led to controversial recommendations that persons in known high-risk groups voluntarily defer from donating blood. In June 1984, after the discovery of the human immunodeficiency virus (HIV), five companies were licensed to produce enzyme-linked immunosorbent assay (EIA, then called ELISA) test kits for detecting HIV antibody. A Food and Drug Administration (FDA) spokesman stated that, "...getting this test out to the blood banks is our No. 1 priority...." Blood bank directors were anxiously waiting to start screening blood with the new test until March 2, 1985, the date the first test kit was approved by the FDA.

In the pre-licensure evaluation, sensitivity and specificity of the test kits were estimated using blood samples from four groups: those with AIDS by CDC criteria, those with other symptoms and signs of HIV infection, those with various autoimmune disorders and neoplastic diseases that could give a false-positive test result, and presumably healthy blood and plasma donors.

Numerous complex issues were discussed even before licensure. Among them were understanding the magnitude of the problem of false-positive test results, and determining whether test-positive blood donors should be notified.

It is now March 2, 1985. The first HIV antibody test kits will arrive in blood banks in the state in a few hours. Meeting with State Epidemiologist to discuss the appropriate use of this test are the Commissioner of Health, the medical director of the regional blood bank, and the chief of the State Drug Abuse Commission.

To help in the discussions, the State Epidemiologist turns to pre-licensure information regarding the sensitivity and specificity of test kit A. The information indicates that the sensitivity of test kit A is 95.0% (0.95) and the specificity is 98.0% (0.98). These and related measures are reviewed below.

NOTES ON SENSITIVITY AND SPECIFICITY

	Actual antibody status		
Test result	Present	Absent	Total
Positive	True positive (A)	False positive (B)	All positive tests (A+B)
Negative	False negative (C)	True negative (D)	All negative tests (C+D)
Total	All with antibody (A+C)	All without antibody (B+D)	Total (A+B+C+D)

Sensitivity - the probability that the test result will be positive when administered to persons who actually have the antibody.

= true positives / all with antibody

Algebraically, sensitivity = A / (A+C)

Specificity - the probability that the test result will be negative when administered to persons who are actually without the antibody.

= true negatives / all without antibody

Algebraically, specificity = D / (B+D).

Predictive-value positive (PVP) - the probability that a person with a positive screening test result actually has the antibody.

= true positives / all with positive test

Algebraically, PVP = A / (A+B).

Predictive-value negative (PVN) - the probability that a person with a negative screening test result actually does not have the antibody.

= true negatives / all with negative test

Algebraically, PVN = D / (C+D).

Question 1: With this information, by constructing a 2-by-2 table, calculate the predictive-value positive and predictive-value negative of the EIA in a hypothetical population of 1,000,000 blood donors. Using a separate 2-by-2 table, calculate PVP and PVN for a population of 1,000 drug users. Assume that the actual prevalence of HIV antibody among blood donors is 0.04% (0.0004) and that of intravenous drug users is 10.0% (0.10).

Answer 1

Instructor's note: Use the blackboard or flipchart to review the construction of the blood bank 2-by-2 table. Save it for Question 9.

A suggested sequence is:

1. Draw and label 2-by-2 table.
2. Indicate total as 1,000,000.
3. The left column total is the total number who are antibody-positive, which is 1,000,000 x prevalence (0.0004) = 400.
4. Right column total is 1,000,000 - 400 = 999,600, total antibody-negative.
5. The "A" cell is the number who are truly positive and who test positive, and is calculated as the left column total times sensitivity, or 400 x 0.95 = 380.
6. The "C" cell can be calculated as 400 - 380 = 20.
7. The "D" cell is the number who are truly negative and who test negative, and is calculated as the right column total times specificity, or 999,600 x 0.98 = 979,608.
8. The "B" cell can be calculated as 999,600 - 979,608 = 19,992.
9. Row totals are next, 20,372 and 979,628.
10. Now review formulas for PVP and PVN, and calculate.

Now let the students do the drug clinic calculations themselves (individually or in teams.)

Blood bank calculations

Given: EIA sensitivity 95.0%
EIA specificity 98.0%
Blood donor prevalence of 0.04% (0.0004)

Test result	Present	Absent	Total	
Positive	380	19,992	20,372	PVP = 380/20,372 = 0.019 (1.9%)
Negative	20	979,608	979,628	PVN = 979,608/979,628 = 0.99998 (99.998%)
Total	400	999,600	1,000,000	

Drug clinic calculations

Given: EIA sensitivity 95.0%
EIA specificity 98.0%
Drug user prevalence of 10% (0.10)

Test result	Present	Absent	Total	
Positive	95	18	113	PVP = 95/113 = 0.841 (84.1%)
Negative	5	882	887	PVN = 882/887 = 0.994 (99.4%)
Total	100	900	1,000	

The blood bank director wants assistance in evaluating the EIA as a test for screening donor blood in the state. In particular, she is concerned about the possibility that some antibody-positive units will be missed by the test, and she wonders about false-positive test results since she is under pressure to develop a notification procedure for EIA-positive donors.

Question 2: Do you think that the EIA is a good screening test for the blood bank? What would you recommend to the blood bank director about notification of EIA-positive blood donors?

Answer 2
At the blood bank, the primary concern is the safety of the blood supply. The EIA is a good but not perfect screening test for the blood bank. Ninety-five percent (380/400) of the antibody-positive units will be screened out, and 2% (20,372/1,000,000) of the donated units will need to be discarded.

Because only 1.9% of the test-positive persons will actually have the antibody (predictive-value positive = 0.019), test-positive blood donors should not be notified on the basis of this test alone.

The chief of the State Drug Abuse Commission has noticed a dramatic increase in AIDS among clients in his intravenous-drug-abuse treatment programs. For planning purposes, he wants to do a voluntary HIV antibody seroprevalence survey of intravenous-drug-abuse clients and would like to assess the feasibility of using the test results as part of behavior-modification counseling.

Question 3: Do you think that the EIA performs well enough to justify informing test-positive clients in the drug abuse clinics that they are positive for HIV?

Answer 3:
For the drug-clinic clients, persons with a positive test will have a 84.1% chance of actually having the antibody (predictive-value positive), while those with a negative test will only have a 0.6% chance of having the antibody (1 - PVN). Although the EIA is much more useful in separating those with and without antibody in the drug clinic than in the blood bank, 16% (1 - PVP) of drug-clinic clients with a positive test result will not actually have the antibody (false positive).

Note, however, that regardless of the test results, counseling of this population is important because they are engaging in high-risk behavior.

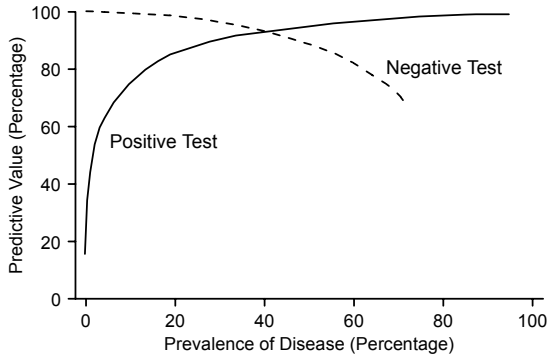
Question 4: If sensitivity and specificity remain constant, what is the relationship of prevalence to predictive-value positive and predictive-value negative?

Answer 4

If the prevalence is high, the predictive-value positive will be high, and the predictive-value negative will be low. If the prevalence is low, the predictive-value positive will be low, and the predictive-value negative will be high.

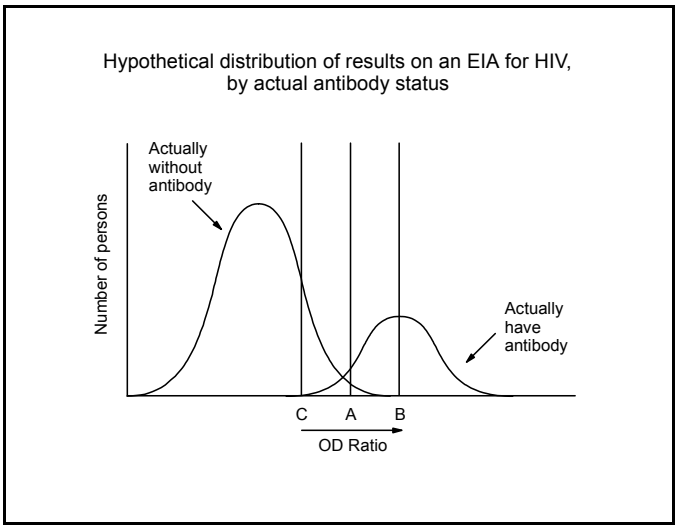
Screening tests perform best when the prevalence of disease is intermediate, between 40% and 60%. This is demonstrated by the following graph.

Relationship between prevalence of disease and predictive value, with sensitivity and specificity held constant at 95 percent
(Adapted from Vecchio, 1966)



From this graph it can be seen that at low prevalence, the predictive-value positive will remain low, even with tests with high sensitivity and specificity. At high prevalence, let's say greater than 90%, the test adds little since the prevalence was so high to begin with.

EIA results are recorded as optical-density (OD) ratios. The OD ratio is the ratio of absorbance of the tested sample to the absorbance of a control sample. The greater the OD ratio, the more "positive" is the test result. The EIA, as with most other screening tests, is not perfect; there is some overlap of optical-density ratios of samples that are actually antibody positive and those that are actually antibody negative. This is illustrated in the following figure.



Establishing the cutoff value to define a positive test result from a negative one is somewhat arbitrary. Suppose that the test manufacturer intiially considered that optical density ratios greater than "A" on the above figure would be called positive.

Question 5: In terms of sensitivity and specificity, what happens if you raise the cutoff from "A" to "B"?

Answer 5
Instructor's Note: Draw the figure on the board or flipchart, and demonstrate which areas of the two curves (those without antibody on the left, and those with antibody on the right) will be included or excluded as you move the cut-off.

Moving the cutoff from "A" to "B" will decrease the sensitivity and will increase the specificity of the test.

Question 6: In terms of sensitivity and specificity, what happens if you lower the cutoff from "A" to "C"?

Answer 6
Moving the cutoff from "A" to "C" will increase the sensitivity and will decrease the specificity of the test.

Question 7: From what you know now, what is the relationship between sensitivity and specificity of a screening test.

Answer 7
By changing the cutoff, if the sensitivity is increased, the specificity is decreased. Conversely, if the sensitivity is decreased, the specificity is increased.

Question 8: Where might the blood bank director and the head of drug treatment want the cutoff point to be for each program? Who would probably want a lower cutoff value?

Answer 8
The blood bank director's primary responsibility is to screen out antibody-positive (probably capable of transmitting the infection) blood at almost any cost. Therefore, she would choose to have a very sensitive test. The cost will be a lower specificity; hence, there will be more false-positive test results, and more blood will be discarded because of false-positive test results.

Because of the severe ramifications of notifying a person that he/she has the antibody, when, in fact, he/she does not (false positive), the director of drug treatment will want a test with high specificity in order to maximize the predictive-value positive.

For these reasons, the blood bank director will probably want a lower cutoff.

PART II

The blood bank director is concerned that, because of the low predictive-value positive of the EIA in the blood donor population, the blood bank personnel cannot properly inform those who are EIA positive of their actual antibody status. For this reason, he wishes to evaluate the Western blot test as a confirmatory test for HIV antibody.

The Western blot test identifies antibodies to specific proteins associated with the human immunodeficiency virus. The Western blot is the most widely used secondary test to detect HIV antibody because its specificity exceeds 99.99%; however, it is not used as a primary screening test because it is expensive and technically difficult to perform. Its sensitivity is thought to be lower than that of the EIA. Because the Western blot test is not yet generally available, the blood bank director is wondering whether the initial EIA-positive results can be confirmed by repeating the EIA and by considering persons to have the antibody only if results of both tests are positive.

The State Epidemiologist suggests that they compare the performance of the repeat EIA and the Western blot as confirmatory tests. To do this, they will use the earlier hypothetical sample of 1,000,000 blood donors. They assume that serum specimens that are initially positive by EIA are then split into two portions; a repeat EIA is performed on one portion and a Western blot on the other portion.

Question 9: What is the actual antibody prevalence in the population of persons whose blood samples will undergo a second test?

Answer 9

In this problem, all persons with a positive EIA result will receive Western blot confirmatory testing. From the hypothetical 1,000,000-person blood-donor population in Question 1, 20,372 persons will have a positive test result. Of these 20,372 persons, 380 (1.9%) will actually have the antibody.

Question 10: Calculate the predictive-value positive of the two sequences of tests: EIA-EIA and EIA-Western blot. Assume that the sensitivity and specificity of the EIA are 95.0% and 98.0%, respectively. Assume that the sensitivity and specificity of the Western blot are 80.0% and 99.99%, respectively. Also assume that the tests are independent, even though they may not be (e.g., those with cross-reactive proteins are likely to cross-react each time).

Answer 10

Note 1: To save time, it may be best to divide the class and have half the class calculate the EIA-EIA and the other half calculate the EIA-WB. The results can then be compared.

Note 2: Avoid the issue of independence of the initial and repeat tests in class if possible. If you are specifically asked, the following brief explanation should suffice.

For this case study, assume that both tests are independent -- the results of the first test do not affect the results of the second test. This is generally not true with series of screening tests; the second test will not "perform" as well on a population that has already been screened with an initial test. Therefore our calculations in this problem will overestimate the predictive-value positive.

Answer 10 continued on next page

Answer 10 continued

An example of non-independence is the repeat EIA. On the initial EIA, some of the false-positive test results will be due to laboratory errors that will be unlikely to be repeated, such as incorrect recording of results. Other initial false-positive test results will be likely to be repeated; for example, if there was a biological reason for the initial false-positive test result (such as antibody cross-reactivity), the repeat test will probably yield a false-positive result as well. In other words, a person who has had one false-positive test result will have a greater chance of having another false-positive test result.

The population of those who actually do not have the antibody in the unscreened population and the population of those who actually do not have the antibody and are being retested are different: those to be retested all had initial false-positive test results. From this, we can see that on repeat testing a larger percentage of those who actually do not have the antibody will have positive test results because these persons all had one initial false-positive test result. Therefore, the specificity of the repeat EIA will be lower than the specificity of the initial EIA on the unscreened population.

For each confirmatory test, the population to be tested is those who were initially EIA-positive from the hypothetical 1,000,000-person blood donor population. From Question 9, the population to have confirmatory testing comprises 20,372 persons, of whom 380 actually have the antibody.

EIA-EIA sequence

Given: EIA sensitivity 95.0%
EIA specificity 98.0%

Test result	Present	Absent	Total	
Positive	361	400	761	PVP = 361 / 761 = 47.4%
Negative	19	19,592	19,611	
Total	380	19,992	20,372	

Persons are considered to be test-positive only if results of both the initial EIA and the repeat EIA are positive. Because only those with an initial positive EIA were included on the above table, the 761 persons with a repeat positive EIA were positive on both the initial and repeat tests. However, of these 761 persons, only 361 actually have the antibody. Therefore, the predictive value positive is 47.4%.

EIA-WB sequence

Given: WB sensitivity 80.0%
WB specificity 99.99%

Test result	Present	Absent	Total	
Positive	304	2	306	PVP = 304 / 306 = 99.3%
Negative	76	19,990	20,066	
Total	380	19,992	20,372	

Answer 10 continued on next page

Answer 10 continued

Persons are considered to be test-positive only if results of both the initial EIA and the confirmatory Western blot are positive. Because only those with an initial positive EIA were included on the above table, the 306 persons with a positive Western blot were positive on both tests. Of these 306 persons, only 304 actually had the antibody. Therefore, the predictive value positive is 99.3% (304/306).

Instructor's Note: Over the years, the sequence many blood banks used for notification purposes was EIA-EIA-Western blot (i.e., the original EIA, a repeat EIA, then a Western blot only for those positive on both EIAs). The following table shows the results of subjecting those blood specimens that are positive on both EIAs to a Western blot. **You need not cover this in class.**

EIA-EIA-WB
Given WB sensitivity of 80.0%
WB specificity of 99.99%

Test result	Present	Absent	Total
Positive	289	0	289
Negative	72	400	472
Total	361	400	761

Predictive-value positive = 289/289 = 100%

missed = 400 - 289 = 111 (including the 20 that were not detected initially, and may wind up bing transfused into patients)

Sensitivity of the entire EIA-EIA-WB sequence = 289/400 = 72%
Specificity of the entire EIA-EIA-WB sequence = 100%, because 'b' cell = 0.

Question 11: Why does the predictive-value positive increase so dramatically with the addition of a second test? Why is the predictive value positive higher for the EIA-WB sequence than for the EIA-EIA sequence?

Answer 11:
From these two examples, we can see that the two most important factors in determining predictive-value positive are the prevalence of the disease and the specificity of the test. In the EIA-EIA example, the predictive-value positive increased from 1.9% after the initial EIA to 47.4% after the repeat EIA, even though the sensitivity and specificity were the same for both initial and repeat tests. This improvement resulted from the higher prevalence of the antibody in the retested population. For the unscreened population, the prevalence was 0.04%, while for the population being retested, the prevalence was 1.9%.

In the EIA-WB example, the predictive-value positive after the Western blot test was 99.3% — a marked improvement over repeating the EIA (PVP = 47.4%). This improvement was a result of the Western blot's very high specificity (99.99%), even though the sensitivity of the Western blot was much lower than that of the EIA (80% and 98%, respectively).

It is now July 1987 and the Governor has asked the State Epidemiologist to evaluate a proposed premarital HIV-antibody-screening program. A bill to establish the program is to be presented to the state legislature tomorrow. An estimated 60,000 people will get married in the state in the next year. The proposed legislation requires that each prospective bride and groom submit a blood sample for EIA testing. Samples that test positive by EIA will undergo confirmatory Western blot testing.

The legislation describes the goal of the screening program to be to decrease inadvertent perinatal or sexual HIV transmission by determining who among those to be married are probably infected with the virus.

Question 12: What criteria would you consider in evaluating this proposed screening program?

Answer 12

Instructor's Note: This is a brainstorming list. Some items on this list are more critical than others. Your class's list need not match this list exactly.

The criteria to be used in evaluating this screening program could include:

Issues related to the test:

- **Availability**. Is the test widely available? Do people know how to use it, what it means?
- **Validity**. How well does the test measure what it is supposed to measure? Does antibody positivity mean that the individual will transmit infection?
- **Reliability**. If you repeat the test on the same person, will you get the same result?
- **Test performance**. What is the yield of the test in terms of sensitivity, specificity, and predictive value?

Issues related to the population:

- **Prevalence of HIV infection**.
- **Coverage of target population**. Does the program address those at risk?
- **Public health importance within this population**

Issues related to the individuals undergoing testing:

- **Acceptability**. Will those who are to be screened accept the program, and will the program be accepted by those performing the follow-up services?
- **Follow-up**. Will there be a mechanism to follow up those with a positive test result?
- **Response / treatment**. Other than notification, is treatment or some other intervention available?
- **Effect**. Does notification affect behavior?
- **Consequences of misclassification.**

Issues related to the public health infrastructure:

- **Feasibility**. What resources and technology are available? What other activities would the screening program displace?
- **Confidentiality**.
- **Other benefits**. Source of surveillance data, etc.
- **Redundancy (data)**. Are these data available from some other source?
- **Alternatives (program)**. Are there other programs that would meet the same objectives?

Issues related to cost, politics

- **Public / political support**.
- **Cost, cost-effectiveness, financing**. What is the cost of the program? [What is cost of NO program?] Is it worth the cost? Who's paying?

(World Health Organization's principles of good screening programs are outlined in Appendix 1)

The following two tables show the results of the testing, assuming that persons getting married have the same actual HIV antibody prevalence as blood donors (0.04%). In 1987, the sensitivity and specificity of the improved EIA Test Kit A available at the time were 97.0% and 99.8%, respectively. The Western blot sensitivity and specificity were 95.0% and 99.99%, respectively.

	Actual antibody status			
Initial EIA	Present	Absent	Total	
Positive	23	120	143	(These 143 will undergo Western blot testing)
Negative	1	59,856	59,857	
Total	24	59,976	60,000	

Follow-up Western blot	Present	Absent	Total
Positive	22	0	22
Negative	1	120	121
Total	23	120	143

With sequential tests: Sensitivity of 92%
Specificity of 100%
Predictive-value positive of 100%

Question 13: Compute the cost of the screening program. Assume a cost of $50.00 for every initial EIA test ($10.00 lab fee and $40.00 health-care-provider visit) and an additional $100.00 for EIA-positive persons who will need additional testing. What is the cost of the screening program in the next year? What is the cost per identified antibody-positive person?

Answer 13

The costs are as follows:

$3,000,000	Initial screening for all (60,000 × $50.00)
14,300	Confirmatory testing of those who are initially EIA positive (143 X $100.00)
$3,014,300	Total for 1 year of testing

In one year, we will identify 22 actual antibody-positive persons. The cost per identified person is $137,013.60 ($3,014,300 /22).

Question 14: What is your final recommendation to the Governor?

Answer 14
Instructors: you need not try to achieve consensus on this question. It is a question intended to provoke discussion.

Most would probably not recommend the screening program to the Governor. In considering the criteria in Question 12, the screening program probably meets the criteria of validity, reliability, and yield (high sensitivity, specificity, and predictive-value positive). The program is definitely not cost-effective; the $3 million anticipated cost for this program that would identify 22 antibody-positive persons exceeds the total AIDS budget for most individual states (at least at that time). The program is likely to be only marginally acceptable to the general population, and there is no proposed mechanism for follow up of antibody-positive persons. It is also unknown whether notification of antibody-positive persons will cause them to change their sexual practices to reduce the risk of sexual transmission or whether notification will deter them from having children. The program only tests persons at one point in time, shortly before marriage. Therefore, the program would miss persons who have children out of wedlock and those who became antibody-positive after marriage.

THE NEW YORK TIMES NATIONAL SUNDAY, JUNE 25, 1989

Illinois Legislature Repeals Requirement for Prenuptial AIDS Tests

By ISABEL WILKERSON
Special to The New York Times

SPRINGFIELD, ILL., June 23 - At the urging of health officials and AIDS specialists, the Illinois Legislature repealed Friday night the only law in the country requiring prenuptial testing for the AIDS virus.

The measure now goes to Gov. James R. Thompson. He has consistently declined comment on whether he will sign it, although pressure on him to do so is intense, including that of his State Health Director, Dr. Bernard Turnock.

A similar testing law in Louisiana was repealed last year, six months after it took effect.

"We made a mistake and we ought to admit it,"said Bill Marovitz, a State Senator from Chicago, urging his colleagues to overturn the testing law.

Prenuptial testing began in Illinois in January 1988 over the strong objection of both the Illinois Department of Public Health and AIDS policy experts.

They said it was an inefficient and expensive way to identify carriers of the virus and diverted already scarce resources from those most at risk.

44 Positive Out of 221,000

Since then, the tests, which detect the antibodies that indicate infection with the human immunodeficiency virus which cases AIDS, have turned up few cases of the disease. Of the 221,000 people who took marriage vows in Illinois since the law took effect, 44 were infected with the HIV virus, tests indicated, and health officials suspect that nearly a dozen of those results may be false. Since the testing was confidential, health officials do not know the outcome of these cases.

The tests have also led thousands of people to leave the state to get married and undetermined numbers of others to put off marriage altogether, health officials said.

Marriages in Illinois fell by nearly a quarter from 99,212 in 1987 to 77,729 in 1988, although the numbers are up slightly so far this year over 1988.

AIDS specialists hailed the repel legislation as long overdue. "It's a 'we-told-you-so' situation," said Andrew Deppe, a spokesman for the AIDS Foundation of Chicago. "Illinois has become a national laughingstock. We've had to spend our energy putting out brush fires instead of working on prevention."

But Penny Pullen, a Republican State Representative from suburban Cook County, who sponsored the prenuptial AIDS testing bill, said repeal of the law would hurt the state's efforts to curb the spread of the virus, "This is a major mistake," Ms.Pullen said. "This will send an unfortunate message to the people of Illinois and the rest of the nation that AIDS is not as serious an epidemic as it was two years ago. And that message is a lie."

Fewer Than Predicted

She pointed to an increase in the number of positive test results in the first half of this year as evidence that the law was working. So far this year, the tests have indicated 18 cases of the AIDS virus among 66,500 newly betrothed people, as against 8 cases among 59,000 people in the same period last year, the Illinois Department of Public Health said.

But officials of the health department said that even with that increase, the agency had found far fewer case in the 18 months of mandatory testing than the 120 cases it originally predicted would be found each year.

The agency also found that the rate of infection among engaged couple's was comparable to those of other low-risks groups. Engaged couples in Illinois and blood donors, both groups considered at very low risk, have rates of infection of about 2 per 10,000.

"The overall rate among these couples is close to the lowest rate ever recorded in this country." said Tom Schafer, a spokesman for the Illinois Department of Public Health.

While even critics say the law has been useful in raising awareness of the AIDS epidemic, state health officials said it was an expensive way to detect carriers of the virus . The test costs each person from $30 to $125, depending on whether testing is done in clinics or in a doctor's office and whether follow-up testing is required. The total cost for Illinois couples last year was $5.4 million, or about $209,00 for each case of HIV infection detected.

Appendix 1

The following 10 principles of successful mass screening programs were proposed by Wilson and Jungner of the World Health Organization in 1968:

1. The condition being sought is an important health problem for the individual and the community.
2. There is an acceptable form of treatment for patients with recognizable disease.
3. The natural history of the condition, including its development from latent to declared disease, is adequately understood;
4. There is a recognizable latent or early symptomatic stage.
5. There is a suitable screening test or examination for detecting the disease at the latent or early symptomatic stage, and this test is acceptable to the population.
6. The facilities required for diagnosis and treatment of patients revealed by the screening program are available.
7. There is an agreed policy on whom to treat as patients.
8. Treatment at the pre-symptomatic, borderline stage of a disease favorably influences its course and prognosis.
9. The cost of the screening program (which would include the cost of diagnosis and treatment) is economically balanced in relation to possible expenditure on medical care as a whole.
10. Case-finding is a continuing process, not a "once and for all" project.

References - Screening for HIV

1. Check WA. Preventing AIDS transmission: should blood donors be screened? *JAMA* 1983; 249:567-70.
2. Goldsmith MF. HTLV-III testing of donor blood imminent; complex issues remain. *JAMA* 1985; 253:173-81.
3. Marwick C. Use of AIDS antibody test may provide more answers. *JAMA* 1985; 253:1694-9.
4. Sivak SL, Wormser GP. Predictive value of a screening test for antibodies to HTLV-III. *Am J Clin Pathol* 1986; 85:700-3.
5. Ward JW, Grindon AJ, Feorino PM, Schable C, Parvin M, Allen JR. Laboratory and epidemiologic evaluation of an enzyme immunoassay for antibodies to HTLV-III. *JAMA* 1986; 256:357-61.
6. Cleary PD, Barry MJ, Mayer KH, et al. Compulsory premarital screening for the human immunodeficiency virus: technical and public health considerations. *JAMA* 1987;258:1757-62.
7. Schwartz JS, Dans PE, Kinosian BP. Human immunodeficiency virus test evaluation, performance, and use: proposals to make good tests better. *JAMA* 1988;259:2574-9.
8. Turnock BJ, Kelly CJ. Mandatory premarital testing for human immunodeficiency virus: the Illinois experience. *JAMA* 1989;261:3415-8.
9. Peterson LR, White CR, and the Premarital Screening Study Group. Premarital screening for antibodies to human immunodeficiency virus in the United States. *Am J Public Health* 1990;80:1087-1090.
9. McKilip J. The effect of mandatory premarital HIV testing on marriage: the case of Illinois. *Am J Public Health* 1991;81:650-3.
11. Albritton WL, Vittinghoff E, Padian NS. Human immunodeficiency virus testing for patient-based and population-based diagnosis. *J Infect Dis* 1996:174(Suppl 2):S176-81.
12. Quinn TC. Acute primary HIV infection. *JAMA* 1997;278:58-62.

SUMMARY OF SCREENING TEST MEASURES

	Condition Truly Present	Condition Truly Absent	
Test positive	True Positive	False Positive	Total Testing Positive
Test negative	False Negative	True Negative	Total Testing Negative
Total	True Prevalence	1 – Prevalence	Size of Population

$$Sensitivity = Prob(T+ \mid D+) = \frac{TP}{TP + FN}$$

$$Specificity = Prob(T- \mid D-) = \frac{TN}{TN + FP}$$

$$Predictive\ value\ positive = Prob(D+ \mid T+) = \frac{TP}{TP + FP}$$

$$Predictive\ value\ negative = Prob(D- \mid T-) = \frac{TN}{TN + FP}$$

Bayes Theorem Formulas for PVP and PVN:

$$PVP = \frac{(Sensitivity)(Prevalence)}{(Sensitivity)(Prevalence) + (1 - Specificity)(1 - Prevalence)}$$

$$1 - PVN = \frac{(1 - Sensitivity)(Prevalence)}{(1 - Sensitivity)(Prevalence) + (Specificity)(1 - Prevalence)}$$